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(54) **SOLID-STATE IMAGE SENSING DEVICE, IMAGE READING APPARATUS, AND IMAGE FORMING APPARATUS**

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H04N 5/378 (2011.01)

(52) **U.S. Cl.**
CPC ***H04N 1/193*** (2013.01); ***H04N 1/0408*** (2013.01); ***H04N 5/2355*** (2013.01); ***H04N 5/361*** (2013.01); ***H04N 5/378*** (2013.01)

(58) **Field of Classification Search**
CPC .. H04N 1/193; H04N 1/0408; H04N 5/2355; H04N 5/361; H04N 5/378
USPC 358/482, 474, 498, 497
See application file for complete search history.

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(57) **ABSTRACT**

A solid-state image sensing device includes: a photoelectric conversion unit that converts light into electrical signals for respective pixels and outputs the electrical signals; a signal separation unit that separates an offset signal, which is generated due to dark current, from each of the electrical signals outputted by the photoelectric conversion unit and outputs image signals which are electrical signals converted from light for the respective pixels; and a signal adding unit that adds the image signals, which is outputted from the signal separation unit, for each group of a plurality of pixels.

17 Claims, 13 Drawing Sheets

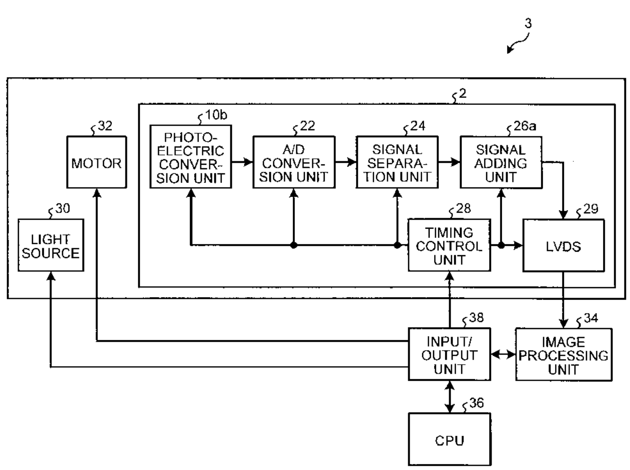

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FIG.1

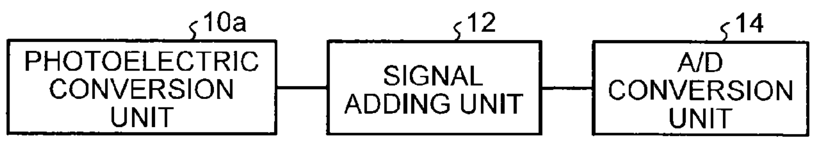

10a
PHOTOELECTRIC CONVERSION UNIT
12
SIGNAL ADDING UNIT
14
A/D CONVERSION UNIT

FIG.2

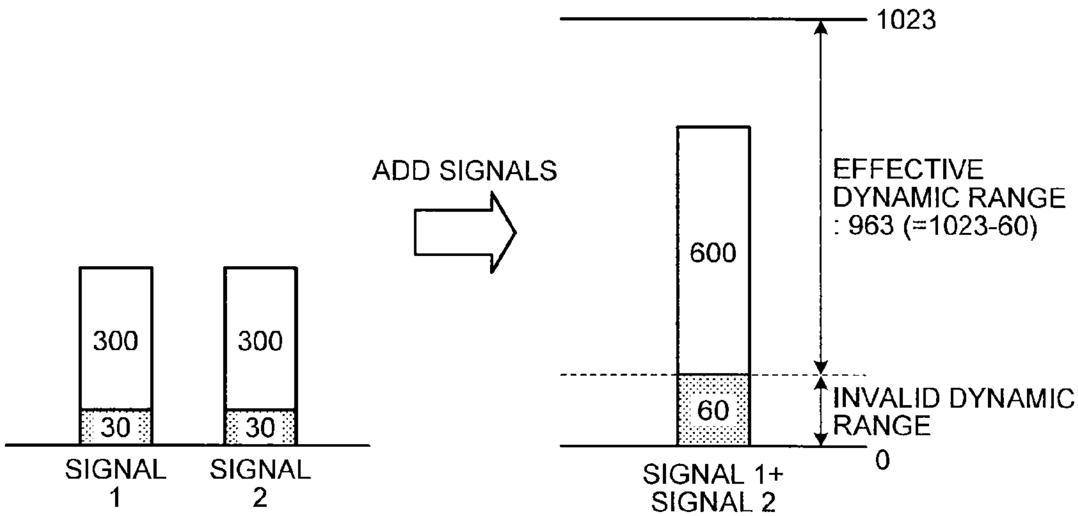

300
30
SIGNAL 1
300
30
SIGNAL 2
ADD SIGNALS
600
60
SIGNAL 1+ SIGNAL 2
1023
EFFECTIVE DYNAMIC RANGE : 963 (=1023-60)
INVALID DYNAMIC RANGE
0

FIG.3

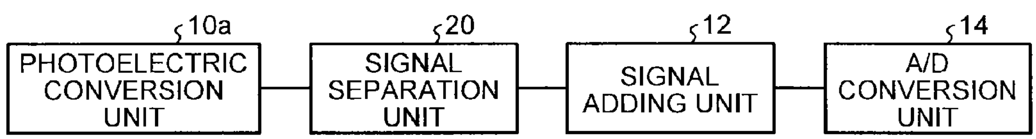

10a
PHOTOELECTRIC CONVERSION UNIT
20
SIGNAL SEPARATION UNIT
12
SIGNAL ADDING UNIT
14
A/D CONVERSION UNIT

FIG.4

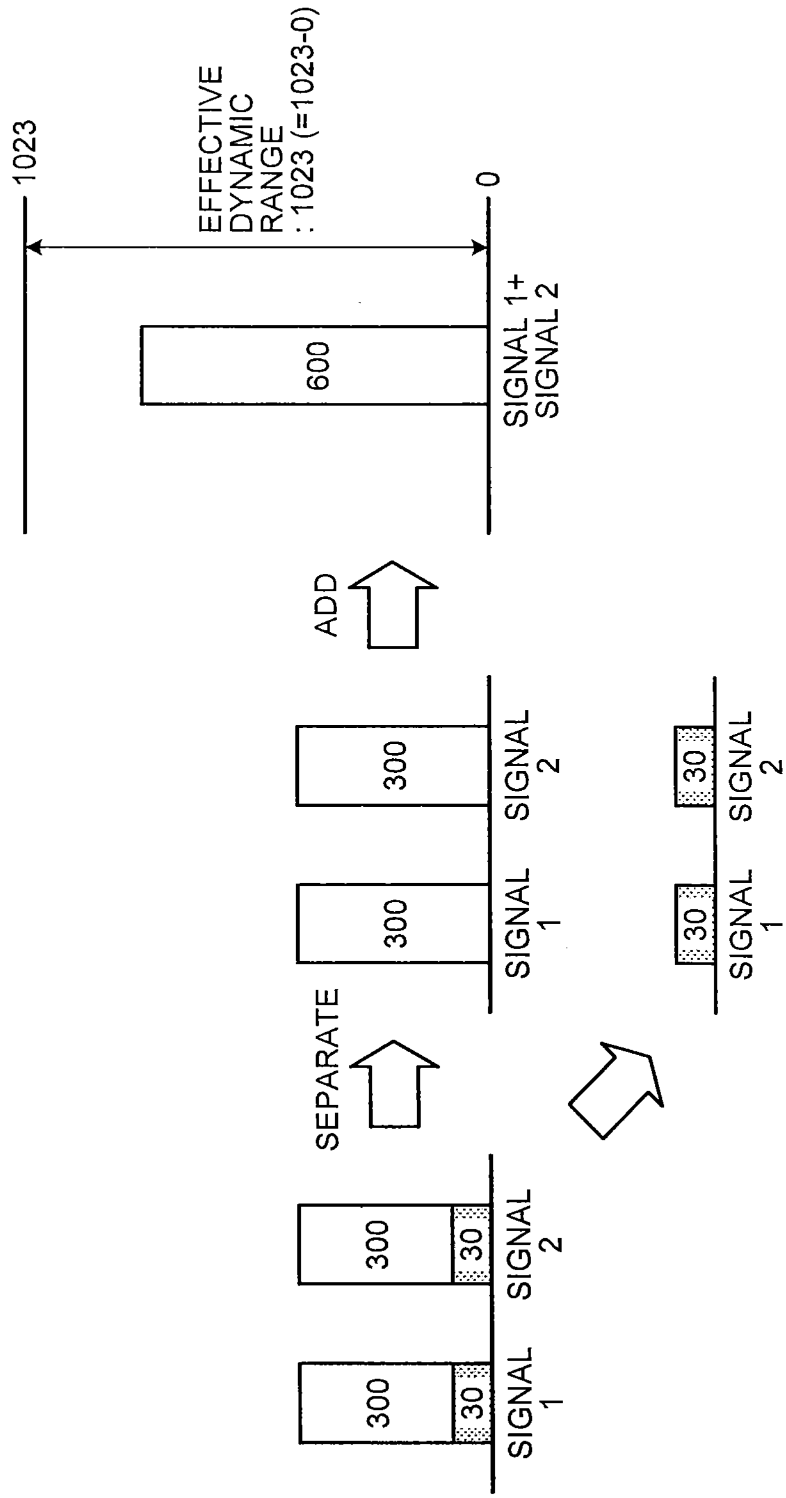

1023
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
0
600
SIGNAL 1+ SIGNAL 2
ADD
300
300
SIGNAL 1
SIGNAL 2
30
30
SIGNAL 1
SIGNAL 2
SEPARATE
300
30
SIGNAL 1
300
30
SIGNAL 2

FIG.5

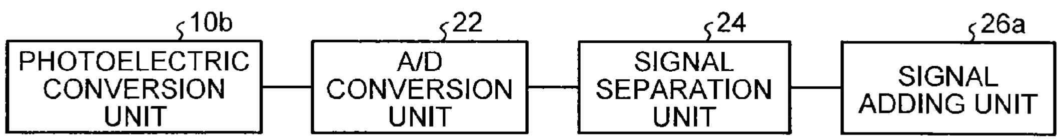

10b
PHOTOELECTRIC CONVERSION UNIT
22
A/D CONVERSION UNIT
24
SIGNAL SEPARATION UNIT
26a
SIGNAL ADDING UNIT

FIG.6

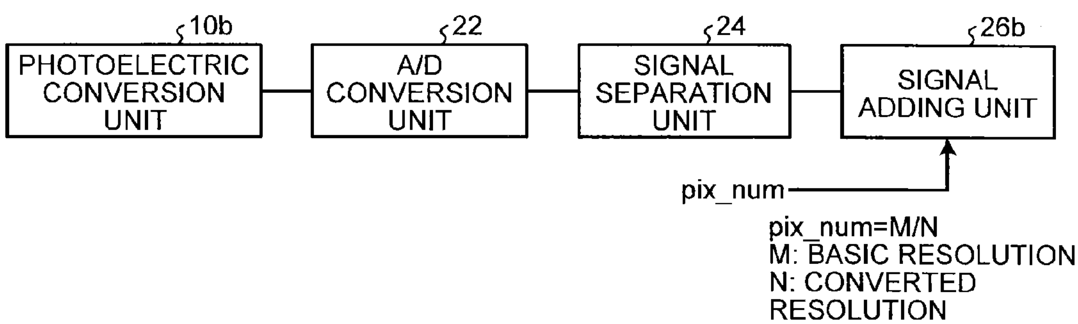

10b
PHOTOELECTRIC CONVERSION UNIT
22
A/D CONVERSION UNIT
24
SIGNAL SEPARATION UNIT
26b
SIGNAL ADDING UNIT
pix_num
pix_num=M/N
M: BASIC RESOLUTION
N: CONVERTED RESOLUTION

FIG.7

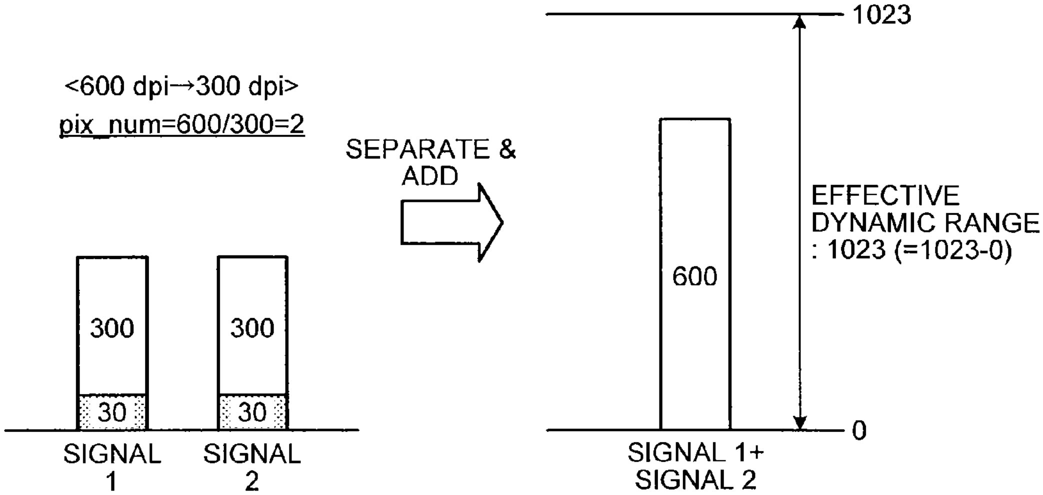

<600 dpi→300 dpi>
pix_num=600/300=2
SEPARATE & ADD
300
30
300
30
SIGNAL 1
SIGNAL 2
1023
600
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
0
SIGNAL 1+ SIGNAL 2

FIG.8

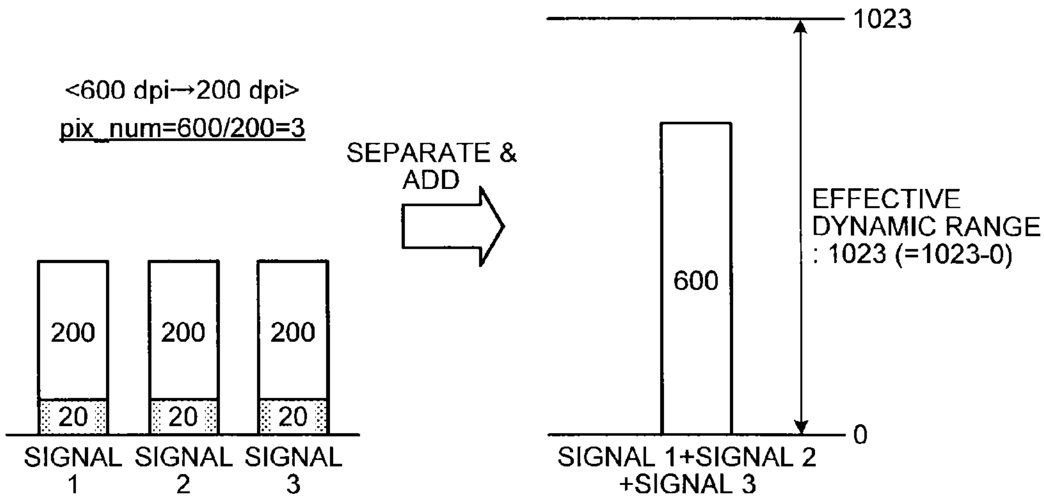

<600 dpi→200 dpi>
pix_num=600/200=3
SEPARATE & ADD
200
20
200
20
200
20
SIGNAL 1
SIGNAL 2
SIGNAL 3
1023
600
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
0
SIGNAL 1+SIGNAL 2 +SIGNAL 3

FIG.9

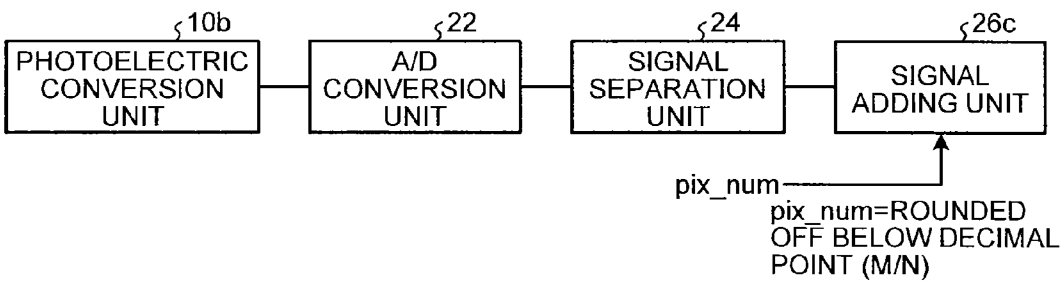

10b
PHOTOELECTRIC CONVERSION UNIT
22
A/D CONVERSION UNIT
24
SIGNAL SEPARATION UNIT
26c
SIGNAL ADDING UNIT
pix_num
pix_num=ROUNDED OFF BELOW DECIMAL POINT (M/N)

FIG.10

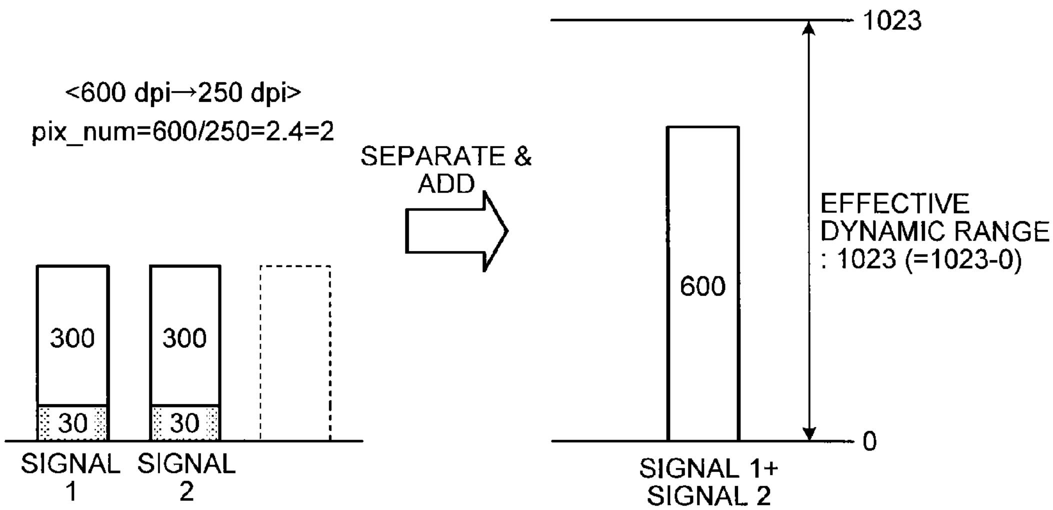

<600 dpi→250 dpi>
pix_num=600/250=2.4=2
300
30
300
30
SIGNAL 1
SIGNAL 2
SEPARATE & ADD
600
1023
0
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
SIGNAL 1+ SIGNAL 2

FIG.11

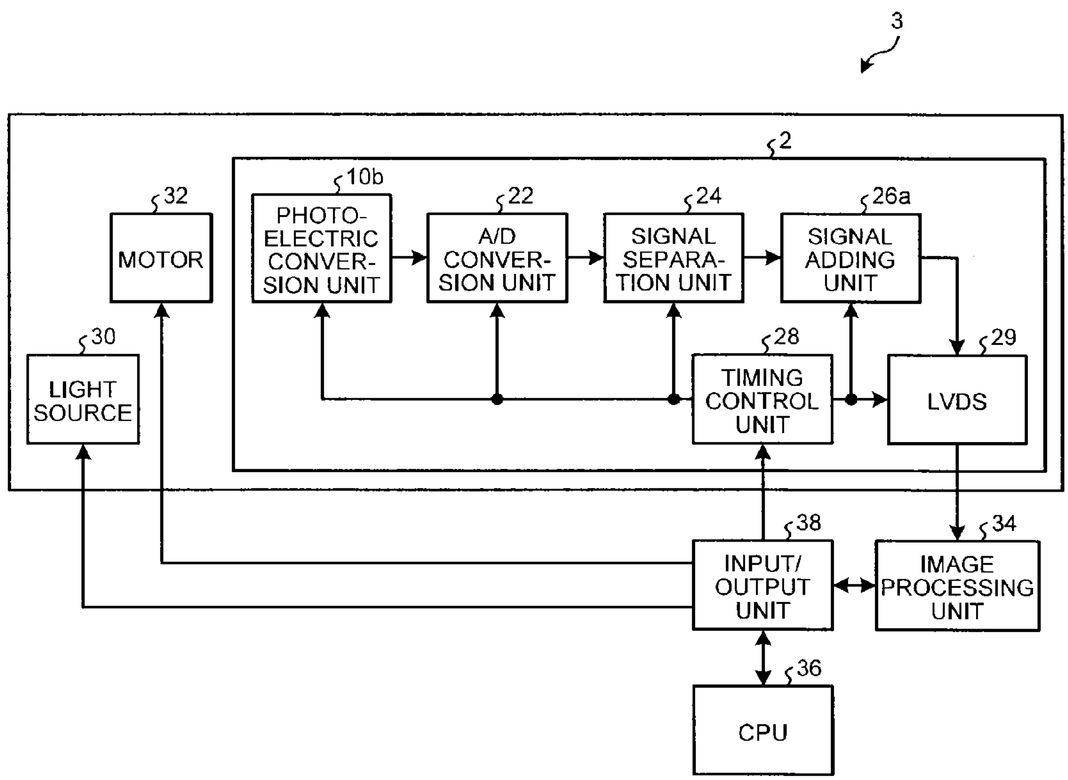

3
2
32
MOTOR
10b
PHOTO-ELECTRIC CONVER-SION UNIT
22
A/D CONVER-SION UNIT
24
SIGNAL SEPARA-TION UNIT
26a
SIGNAL ADDING UNIT
30
LIGHT SOURCE
28
TIMING CONTROL UNIT
29
LVDS
38
INPUT/ OUTPUT UNIT
34
IMAGE PROCESSING UNIT
36
CPU

FIG.12

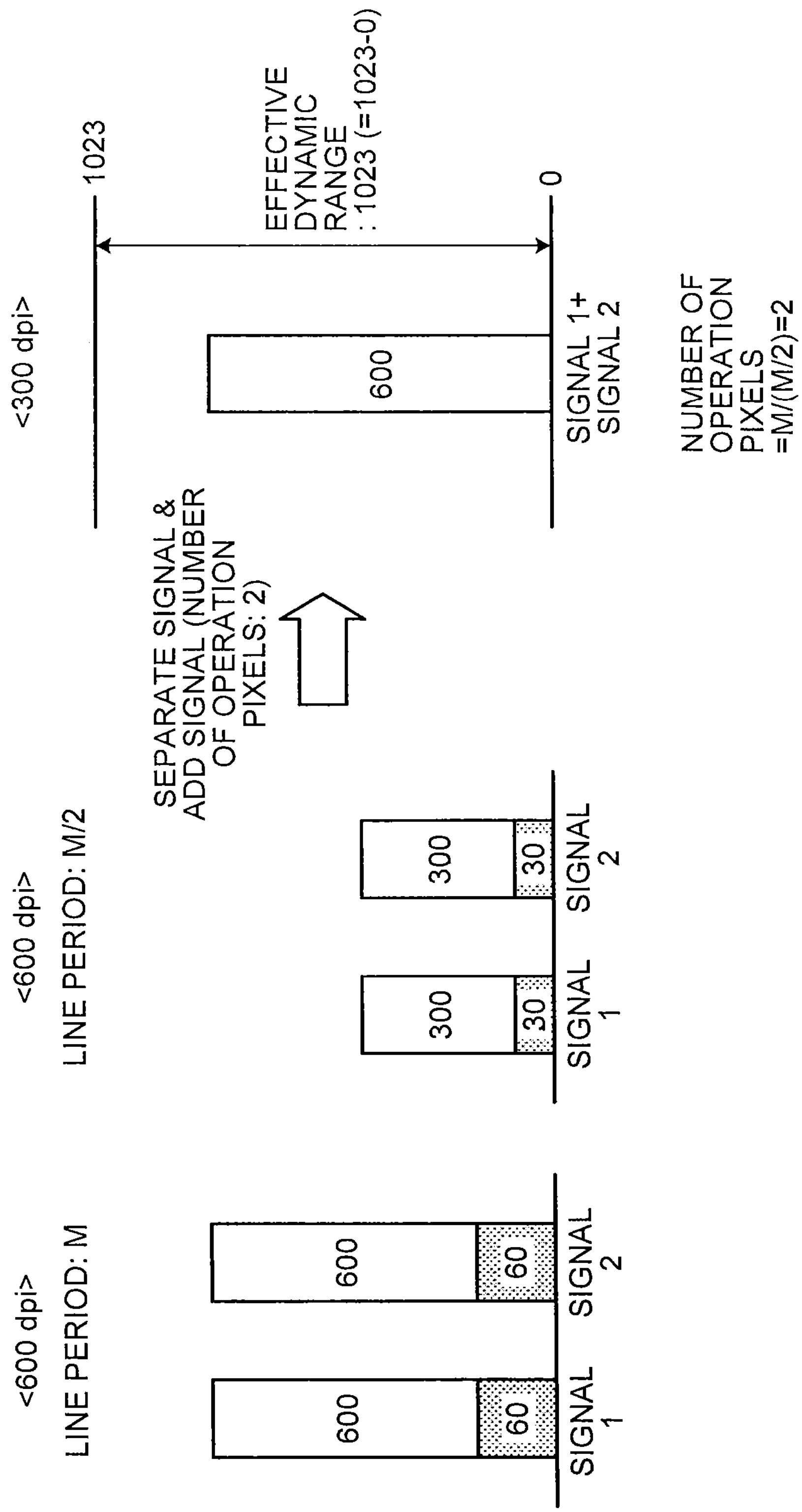

<600 dpi>
LINE PERIOD: M
600
60
SIGNAL 1
600
60
SIGNAL 2
<600 dpi>
LINE PERIOD: M/2
300
30
SIGNAL 1
300
30
SIGNAL 2
SEPARATE SIGNAL & ADD SIGNAL (NUMBER OF OPERATION PIXELS: 2)
<300 dpi>
600
SIGNAL 1+ SIGNAL 2
1023
0
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
NUMBER OF OPERATION PIXELS =M/(M/2)=2

FIG. 13

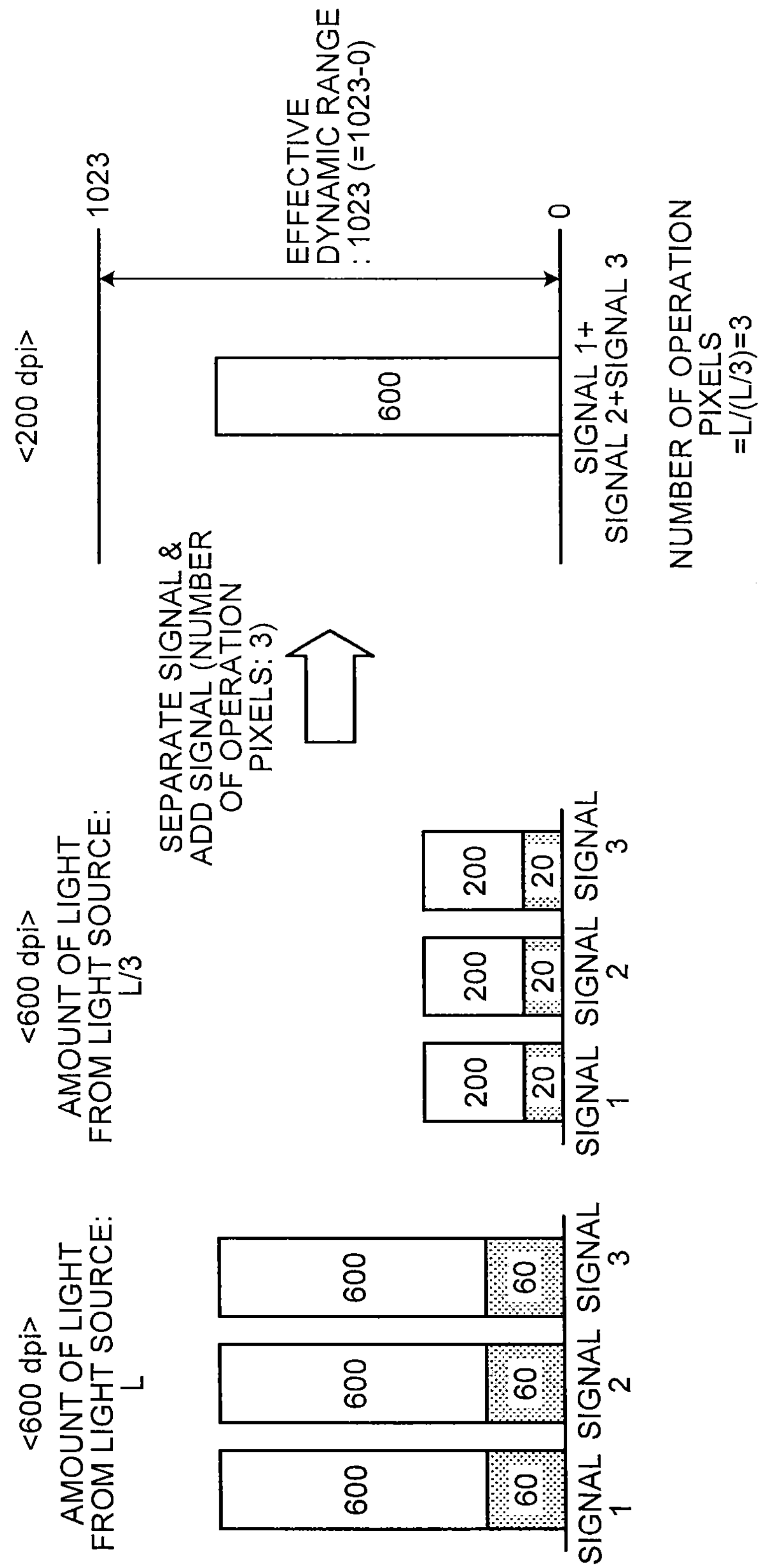

<600 dpi>
AMOUNT OF LIGHT FROM LIGHT SOURCE: L
600
60
SIGNAL 1
SIGNAL 2
SIGNAL 3
<600 dpi>
AMOUNT OF LIGHT FROM LIGHT SOURCE: L/3
200
20
SEPARATE SIGNAL & ADD SIGNAL (NUMBER OF OPERATION PIXELS: 3)
<200 dpi>
1023
0
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
SIGNAL 1+ SIGNAL 2+SIGNAL 3
NUMBER OF OPERATION PIXELS =L/(L/3)=3

FIG.14

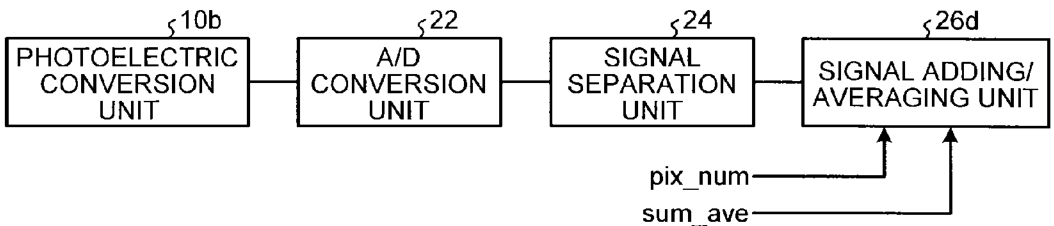

10b
PHOTOELECTRIC CONVERSION UNIT
22
A/D CONVERSION UNIT
24
SIGNAL SEPARATION UNIT
26d
SIGNAL ADDING/ AVERAGING UNIT
pix_num
sum_ave

FIG.15

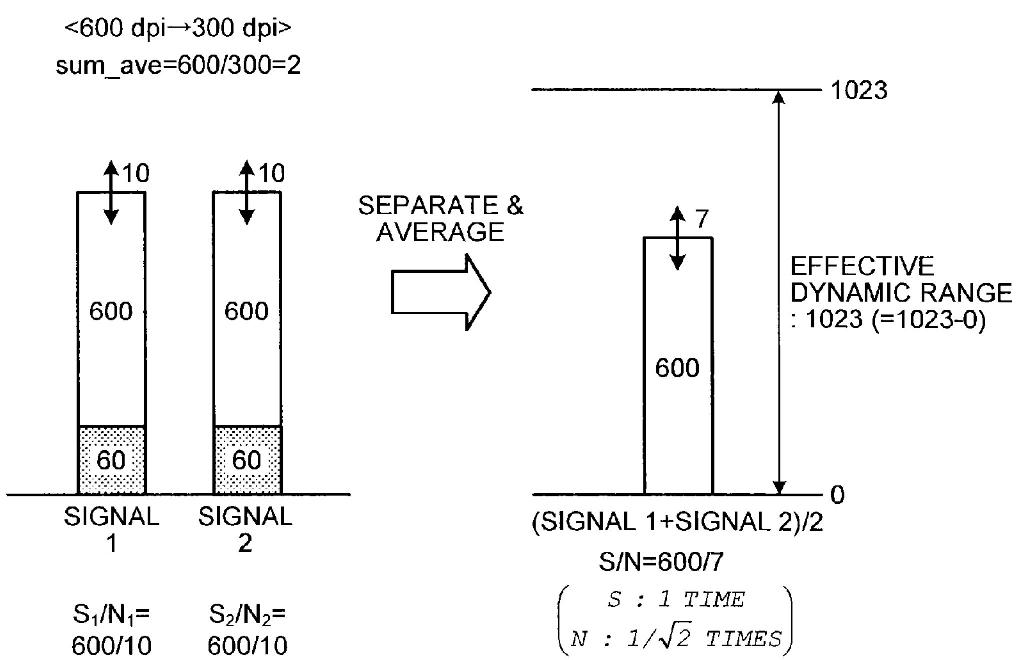
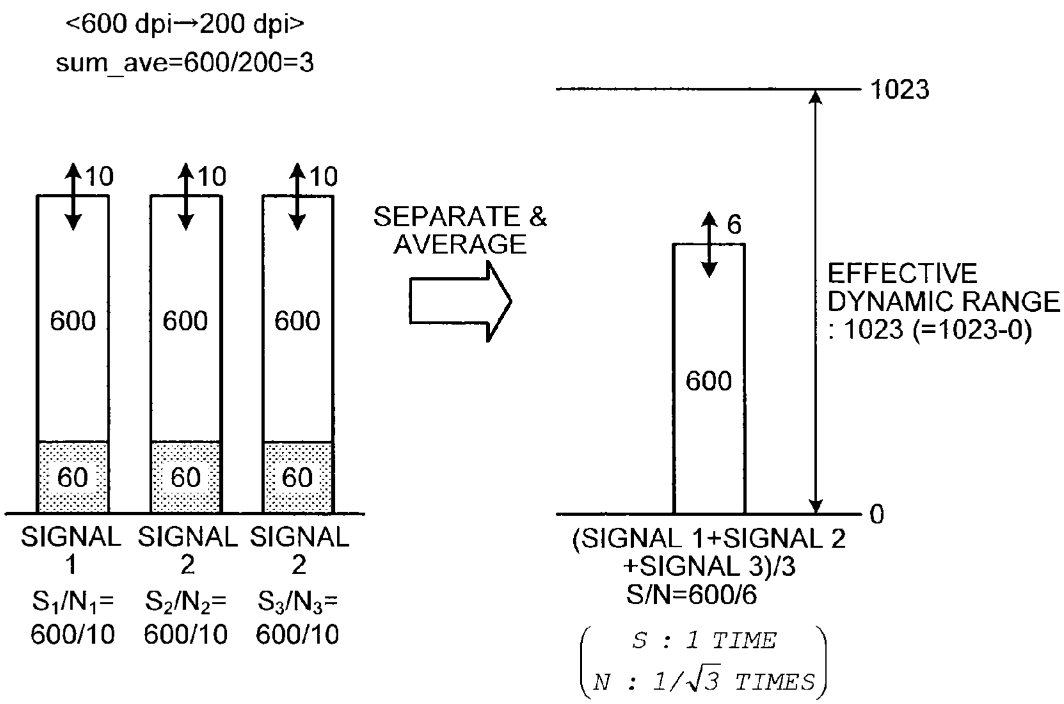

<600 dpi→300 dpi>
sum_ave=600/300=2
10
10
600
600
60
60
SIGNAL 1
SIGNAL 2
S1/N1= 600/10
S2/N2= 600/10
SEPARATE & AVERAGE
1023
7
600
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
0
(SIGNAL 1+SIGNAL 2)/2
S/N=600/7
S : 1 TIME
N : 1/√2 TIMES

FIG.16



<600 dpi→200 dpi>
sum_ave=600/200=3
10
10
10
600
600
600
60
60
60
SIGNAL 1
SIGNAL 2
SIGNAL 2
S1/N1= 600/10
S2/N2= 600/10
S3/N3= 600/10
SEPARATE & AVERAGE
1023
6
600
0
EFFECTIVE DYNAMIC RANGE : 1023 (=1023-0)
(SIGNAL 1+SIGNAL 2 +SIGNAL 3)/3
S/N=600/6
S : 1 TIME
N : 1/√3 TIMES

FIG.17

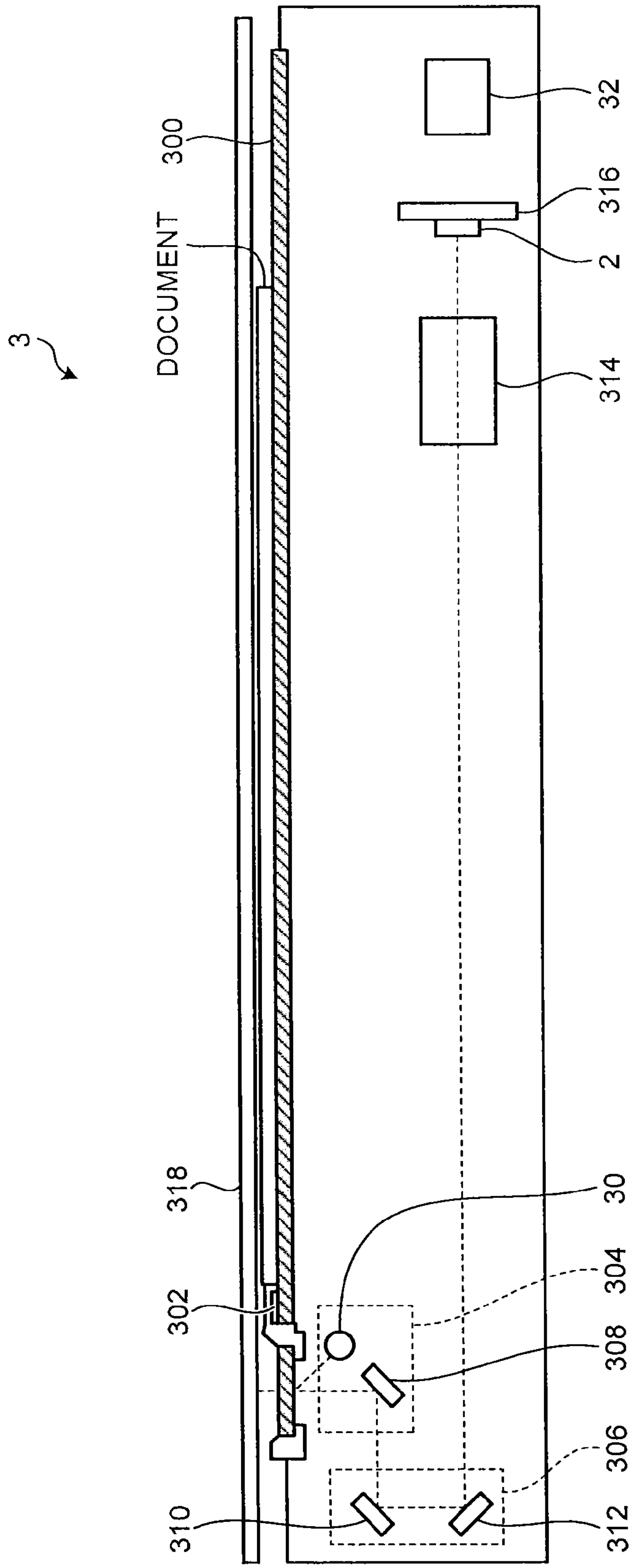
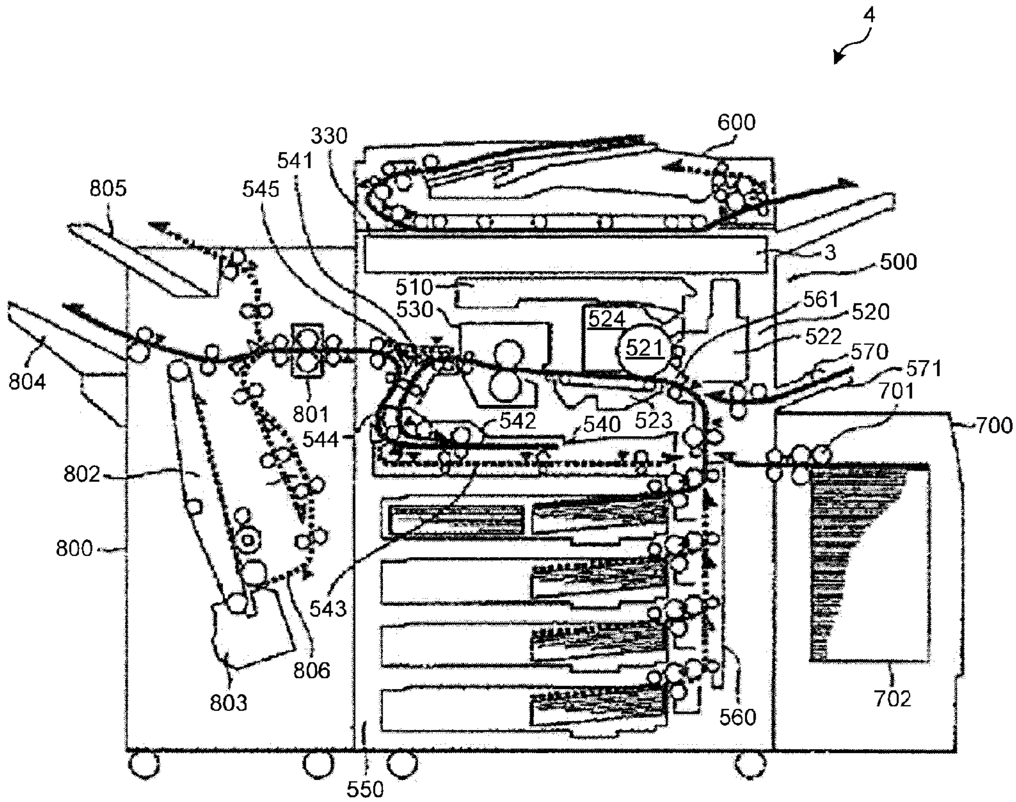


FIG.18


4
330
600
541
545
805
3
500
510
530
524
521
561
520
522
570
571
701
700
804
801
542
540
523
544
802
800
543
806
803
560
702
550

SOLID-STATE IMAGE SENSING DEVICE, IMAGE READING APPARATUS, AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2013-014518 filed in Japan on Jan. 29, 2013.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a solid-state image sensing device, an image reading apparatus, and an image forming apparatus.

2. Description of the Related Art

A resolution conversion technique is conventionally known which increases an image reading rate and reduces the size of read image data by reading images at a resolution lower than the resolution at which the image reading apparatus can perform reading. By reading images at a lowered resolution, the amount of light emission from a reading light source can be kept down and thereby power saving can be achieved.

In a case where the resolution in image reading is lowered to enhance the productivity in reading of a document, an image reading period (line period) in a main-scanning direction is shortened, for example. In this case, accumulation time of electric charge, which are generated by photoelectrical conversion by an image sensor to read the document, may be shortened and thereby an output level of the image sensor may decrease (i.e., an SN ratio regarding the image may be deteriorated and image quality may be degraded). For preventing the SN ratio regarding the image from being deteriorated by the resolution conversion, it is known to add successive pixel data so as to suppress the decrease in the output level of the image sensor.

Japanese Patent Application Laid-open No. 2004-048167 discloses an image reading apparatus having a mode in which a signal formed by adding two image signals is used as pixel data and a mode in which pixel signals of even-numbered light receiving elements are used as image data so as to perform read operation at a high rate in a sub-scanning direction.

However, in image sensors, dark current flows even when no light is incident. As a result, electric charge is stored as an offset. That is, when pixel signals including the offsets are added for resolution conversion, a dynamic range of image data after resolution conversion is disadvantageously narrowed.

In view of the above, there is a need to provide a solid-state image sensing device, an image reading apparatus, and an image forming apparatus which can prevent the dynamic range of image data from being narrowed even when resolution conversion is performed.

SUMMARY OF THE INVENTION

It is an object of the present invention to at least partially solve the problems in the conventional technology.

A solid-state image sensing device includes: a photoelectric conversion unit that converts light into electrical signals for respective pixels and outputs the electrical signals; a signal separation unit that separates an offset signal, which

is generated due to dark current, from each of the electrical signals outputted by the photoelectric conversion unit and outputs image signals which are electrical signals converted from light for the respective pixels; and a signal adding unit that adds the image signals, which is outputted from the signal separation unit, for each group of a plurality of pixels.

An image reading apparatus includes a solid-state image sensing device as described above.

A solid-state image sensing device includes: a photoelectric conversion unit that converts light into electrical signals for respective pixels and outputs the electrical signals; a signal separation unit that separates an offset signal, which is generated due to dark current, from each of the electrical signals outputted by the photoelectric conversion unit and outputs image signals which are electrical signals converted from light for the respective pixels; and a signal averaging unit that averages the image signals, which is outputted from the signal separation unit, for each group of a plurality of pixels.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating a schematic configuration of a solid-state image sensing device which enables resolution conversion;

FIG. **2** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **1**;

FIG. **3** is a block diagram illustrating a schematic configuration of a solid-state image sensing device according to a first embodiment;

FIG. **4** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **3**;

FIG. **5** is a block diagram illustrating a schematic configuration of a solid-state image sensing device according to a second embodiment;

FIG. **6** is a block diagram illustrating a schematic configuration of a first specific example of the solid-state image sensing device according to the second embodiment;

FIG. **7** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **6** with a resolution being converted from a basic resolution (600 dpi) to a resolution of 300 dpi;

FIG. **8** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **6** with the resolution being converted from the basic resolution (600 dpi) to a resolution of 200 dpi;

FIG. **9** is a block diagram illustrating a schematic configuration of a second specific example of the solid-state image sensing device according to the second embodiment;

FIG. **10** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **9** with the resolution being converted from the basic resolution (600 dpi) to a resolution of 250 dpi;

FIG. **11** is a block diagram illustrating a configuration example of an image reading apparatus including a third specific example of the solid-state image sensing device according to the second embodiment;

FIG. **12** illustrates a first operation example of the image reading apparatus illustrated in FIG. **11**;

FIG. **13** illustrates a second operation example of the image reading apparatus illustrated in FIG. **11**;

FIG. **14** is a block diagram illustrating a schematic configuration of a modified example of the solid-state image sensing device included in the image reading apparatus;

FIG. **15** illustrates a first operation example of the modified example of the solid-state image sensing device illustrated in FIG. **14**;

FIG. **16** illustrates a second operation example of the modified example of the solid-state image sensing device illustrated in FIG. **14**;

FIG. **17** is a side view of the image reading apparatus which incorporates the solid-state image sensing device according to the embodiments; and

FIG. **18** is a side view of an image forming apparatus which incorporates the image reading apparatus having the solid-state image sensing device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First, the background that the present invention has been invented will be described. FIG. **1** is a block diagram illustrating a schematic configuration of a solid-state image sensing device which enables resolution conversion. For example, the solid-state image sensing device is a CMOS linear image sensor including a photoelectric conversion unit **10***a*, a signal adding unit **12**, and an A/D conversion unit **14**.

For example, the photoelectric conversion unit **10***a* is formed by arraying a plurality of photoelectric conversion elements (not illustrated), such as photo diodes, to convert light into electrical signals for respective pixels and to output the converted electrical signals. The signal adding unit **12** adds pixel data, represented by electric charge accumulated in the photoelectric conversion unit **10***a* upon reception of light, for a plurality of consecutive pixels. The A/D conversion unit **14** converts pixel data, each obtained by adding image data by the signal adding unit **12**, into a 10-bit digital signal for example.

In the solid-state image sensing device illustrated in FIG. **1**, dark current flows in the photoelectric conversion elements even when no light is incident. In other words, when the photoelectric conversion unit **10***a* outputs pixel data represented by the electric charge accumulated upon light reception, an offset signal caused by the dark current is included in the pixel data.

Thus, each of a plurality of pixel data includes the offset signal caused by the dark current. Therefore, when the signal adding unit **12** adds (i.e., performs resolution conversion on) a plurality of pixel data outputted by the photoelectric conversion unit **10***a*, respective offset signals are also added and an effective dynamic range of the image data is thereby narrowed.

FIG. **2** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **1**. For example, as illustrated in FIG. **2**, two photoelectric conversion elements of the photoelectric conversion unit **10***a* output respective signals **1** and **2**. Each of these two signals **1** and **2** includes, for example, an offset signal with a value of 30 and effective image data (an image signal) with a value of 300. When the signal adding unit **12** adds the signals **1** and **2**, the value of the offset signal becomes 60 and the value of the effective pixel data becomes 600.

Therefore, the sum of the offset signal with a value of 60 and the pixel data with a value of 600 ends up being included in the dynamic range. The offset signal forms an invalid range within the dynamic range. Accordingly, when the dynamic range is 10 bits (**0** to **1023**), the effective dynamic range is equal to 963 (=1023-60). Thus, when the pixel data including the offset signals are added, the dynamic range of the image signal is narrowed.

First Embodiment

Next, a first embodiment of a solid-state image sensing device will be described in detail. FIG. **3** is a block diagram illustrating a schematic configuration of the solid-state image sensing device according to the first embodiment. The solid-state image sensing device according to the first embodiment is a CMOS linear image sensor, for example, and includes a photoelectric conversion unit **10***a*, a signal separation unit **20**, a signal adding unit **12**, and an A/D conversion unit **14**. In the solid-state image sensing device illustrated in FIG. **3**, component members substantially identical to those forming the solid-state image sensing device illustrated in FIG. **1** are designated by identical reference numerals.

The signal separation unit **20** separates (deletes) an offset signal, generated due to the dark current, from each of the electrical signals outputted by the photoelectric conversion unit **10***a*, and outputs, to the signal adding unit **12**, image signals which are electrical signals converted from light for respective pixels. Here, the signal separation unit **20** separates the offset signal by, for example, analog correlated double sampling (CDS).

The signal adding unit **12** adds the image signals outputted by the signal separation unit **20** for each group of a plurality of consecutive pixels. For example, the A/D conversion unit **14** converts pixel data (image signals), each obtained by adding image data by the signal adding unit **12**, into a 10-bit digital signal. This indicates that the image data which are converted into the digital signal by the A/D conversion unit **14** does not include any offset signal.

FIG. **4** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **3**. For example, as illustrated in FIG. **4**, two photoelectric conversion elements of the photoelectric conversion unit **10***a* output respective signals **1** and **2**. Each of these two signals **1** and **2** includes, for example, an offset signal with a value of 30 and effective image data (an image signal) with a value of 300. The signal separation unit **20** separates the offset signal with a value of 30 from each of the signals **1** and **2**, and outputs, to the signal adding unit **12**, image signals with a value of 300 which are electrical signals converted from light for the respective pixels. The signal adding unit **12** adds only the image signals with their offset signals being separated, so that an effective pixel data value of 600 is obtained.

Therefore, only the pixel data with a value of 600 are included in the dynamic range.

This indicates that the dynamic range does not include any invalid signal. Therefore, when the dynamic range is 10 bits (**0** to **1023**), the effective dynamic range is equal to 1023 (=1023−0). Thus, when the pixel data with their offset signals being separated are added, it becomes possible to prevent the dynamic range of the image signal from being narrowed.

Second Embodiment

Next, a second embodiment of a solid-state image sensing device will be described in detail. FIG. **5** is a block diagram illustrating a schematic configuration of the solid-state image sensing device according to the second embodiment. The solid-state image sensing device according to the second embodiment is a CMOS linear image sensor, for example, and includes a photoelectric conversion unit **10**_b_, an A/D conversion unit **22**, a signal separation unit **24**, and a signal adding unit **26**_a_.

The photoelectric conversion unit **10**_b_ is formed by arraying a plurality of photoelectric conversion elements (not illustrated), such as photo diodes, to convert light into electrical signals for respective pixels and to output the converted electrical signals. The photoelectric conversion unit **10**_b_ outputs, to the A/D conversion unit **22**, voltages corresponding to electric charge accumulated in accordance with light. The A/D conversion unit **22** converts the electrical signals, which have been outputted for the respective pixels by the photoelectric conversion unit **10**_b_, into parallel 10-bit digital signals for example, and outputs the converted digital signals to the signal separation unit **24**.

The signal separation unit **24** separates (deletes) an offset signal, generated due to the dark current, from each of the digit signals outputted by the A/D conversion unit **22**, and outputs, to the signal adding unit **26**_a_, image signals which are electrical signals converted from light for respective pixels. Here, the signal separation unit **24** separates an offset signal by, for example, digital correlated double sampling (CDS).

The signal adding unit **26**_a_ adds the image signals outputted by the signal separation unit **24** for each group of a plurality of consecutive pixels. This indicates that the offset signal is not included in the image signals to be added by the signal adding unit **26**_a_.

The solid-state image sensing device illustrated in FIG. **5** separates the offset signal after the pixel data is converted into a digital signal. In other words, unlike the solid-state image sensing device illustrated in FIG. **2**, the solid-state image sensing device in the present embodiment does not need to electrically hold an analog signal level for execution of addition processing. The pixel data converted into a digital signal can be held in a register or a memory.

In other words, since an offset signal is separated after the pixel data is converted into a digital signal, the solid-state image sensing device illustrated in FIG. **5** does not need the capacitance for retaining the electric charge in the photoelectric conversion unit **10**_b_. It is also not necessary to provide a switch that switches accumulation and discharge of electric charge in and from the capacitance in accordance with the number of signals (=the number of pixels) to be added. As a result, a circuit size can be reduced. Therefore, it becomes possible to prevent increase in parasitic capacitance due to formation of the capacitance and the switch.

First Specific Example

FIG. **6** is a block diagram illustrating a schematic configuration of a first specific example of the solid-state image sensing device according to the second embodiment. For example, as illustrated in FIG. **6**, the first specific example of the solid-state image sensing device is a CMOS linear image sensor including a photoelectric conversion unit **10**_b_, an A/D conversion unit **22**, a signal separation unit **24**, and a signal adding unit **26**_b_. In the solid-state image sensing device illustrated in FIG. **6**, component members substantially identical to those forming the solid-state image sensing device illustrated in FIG. **5** are designated by identical reference numerals.

The signal adding unit **26**_b_ adds image signals outputted by the signal separation unit **24** for each group of a plurality of consecutive pixels. Here, the signal adding unit **26**_b_ adds the image signals for each group of pixels the number of which corresponds to a ratio between resolutions before and after the resolution conversion performed for resolution reduction. More specifically, the signal adding unit **26**_b_ determines the number of signals to be added (the number of operation pixels) based on pix_num. The parameter pix_num is a ratio (M/N) of a basic resolution (such as a readable resolution) M to a converted resolution N. For example, the value of the converted resolution N is configured to be variable.

FIG. **7** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **6** with the resolution being converted from a basic resolution (600 dpi) to a resolution of 300 dpi. FIG. **8** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **6** with the resolution being converted from the basic resolution (600 dpi) to a resolution of 200 dpi. In both the operation examples illustrated in FIGS. **7** and **8**, the solid-state image sensing device implements resolution conversion without causing the effective dynamic range to be narrowed.

Second Specific Example

FIG. **9** is a block diagram illustrating a schematic configuration of a second specific example of the solid-state image sensing device according to the second embodiment. The second specific example of the solid-state image sensing device is a CMOS linear image sensor, for example, and includes a photoelectric conversion unit **10**_b_, an A/D conversion unit **22**, a signal separation unit **24**, and a signal adding unit **26**_c_, as illustrated in FIG. **9**. In the solid-state image sensing device illustrated in FIG. **9**, component members substantially identical to those forming the solid-state image sensing device illustrated in FIG. **5** are designated by identical reference numerals.

The signal adding unit **26**_c_ adds image signals outputted by the signal separation unit **24** for each group of a plurality of consecutive pixels. Here, the signal adding unit **26**_c_ adds the image signals for each group of pixels the number of which is a maximum integer equal to or less than a ratio between resolutions before and after the resolution conversion performed for resolution reduction. More specifically, the signal adding unit **26**_c_ determines the number of signals to be added (the number of operation pixels) based on pix_num. Note that the signal adding unit **26**_c_ rounds off the result of the aforementioned M/N operation below the decimal point.

FIG. **10** illustrates an operation example of the solid-state image sensing device illustrated in FIG. **9** with the resolution being converted from the basic resolution (600 dpi) to a resolution of 250 dpi. As illustrated also in FIG. **10**, the signal adding unit **26**_c_ rounds off the result of the M/N operation below the decimal point. As a result, pix_num is equal to 600/200=2.4=2, and so the number of operation pixels is 2. In this operation example, the solid-state image sensing device also implements resolution conversion without causing the effective dynamic range to be narrowed.

FIG. **11** is a block diagram illustrating a configuration example of an image reading apparatus **3** including a third specific example of the solid-state image sensing device (solid-state image sensing device **2**) according to the second embodiment. In the image reading apparatus **3** illustrated in FIG. **11**, component members substantially identical to those forming the solid-state image sensing device illustrated in FIG. **5** are designated by identical reference numerals.

The image reading apparatus **3** includes a solid-state image sensing device **2**, a light source **30**, a motor **32**, an image processing unit **34**, a CPU **36**, and an input/output unit

38. For example, the solid-state image sensing device **2** includes a photoelectric conversion unit **10**_b_, an A/D conversion unit **22**, a signal separation unit **24**, a signal adding unit **26**_a_, a timing control unit **28**, and an LVDS **29**.

The timing control unit **28** drives the photoelectric conversion unit **10**_b_, the A/D conversion unit **22**, the signal separation unit **24**, the signal adding unit **26**_a_, and the LVDS **29** with set timing. The image reading apparatus **3** irradiates a document with light from the light source **30**. The image reading apparatus **3** then reads a document image with an unshown substrate, on which the solid-state image sensing device **2** is mounted, while performing scanning with the motor **32**. The LVDS **29** outputs image data, read with the solid-state image sensing device **2**, to the image processing unit **34**. The CPU **36** controls the timing control unit **28**, the light source **30**, the motor **32**, and the image processing unit **34** via the input/output unit **38**.

FIG. **12** illustrates a first operation example of the image reading apparatus **3** illustrated in FIG. **11**. To enhance the productivity in document reading, the image reading apparatus **3** changes a line period M to, for example, a line period M/2. However, "the line period" is nearly equal to (≈) "time during which the photoelectric conversion unit **10**_b_ accumulates electric charge". Accordingly, if the line period is reduced to half for example, the accumulation time of electric charge is also reduced to half, which leads to decrease in output level of the photoelectric conversion unit **10**_b_ (=deterioration in S/N ratio regarding an image). Therefore, the image reading apparatus **3** determines the number of operation pixels based on a basic line period (M) and a line period (M/2) after resolution conversion. For example, the image reading apparatus **3** sets the number of operation pixels for addition processing to M/(M/2)=2. Therefore, the image reading apparatus **3** can prevent the dynamic range from being narrowed, enhance the productivity in image reading, and can also prevent the S/N ratio regarding the image from being deteriorated.

FIG. **13** illustrates a second operation example of the image reading apparatus **3** illustrated in FIG. **11**. In the second operation example, the image reading apparatus **3** suppresses power consumption by reducing the amount of light from the light source **30** in image reading. However, if the amount of light from the light source is reduced to, for example, ⅓, the electric charge that can be accumulated by the photoelectric conversion unit **10**_b_ is also reduced to ⅓. Accordingly, at the time of resolution conversion, the image reading apparatus **3** sets the number of operation pixels for addition processing to L/(L/3)=3, where L represents a basic light amount and L/3 represents the amount of light from the light source after light amount reduction. As a result, the image reading apparatus **3** can prevent the dynamic range from being narrowed, enhance the productivity in image reading while reducing power consumption, and can also prevent the S/N ratio regarding the image from being deteriorated.

FIG. **14** is a block diagram illustrating a schematic configuration of a modified example of the solid-state image sensing device **2** included in the image reading apparatus **3**. For example, as illustrated in FIG. **14**, the modified example of the solid-state image sensing device **2** includes a photoelectric conversion unit **10**_b_, an A/D conversion unit **22**, a signal separation unit **24**, and a signal adding/averaging unit **26**_d_. In the modified example of the solid-state image sensing device **2** illustrated in FIG. **14**, component members substantially identical to those forming the solid-state image sensing device illustrated in FIG. **5** are designated by identical reference numerals.

The signal adding/averaging unit **26**_d_ performs either addition or averaging of image signals outputted by the signal separation unit **24** for each group of a plurality of consecutive pixels. Here, the signal adding/averaging unit **26**_d_ performs the aforementioned addition or averaging of image signals in accordance with pix_num or sum_ave.

In the modified example of the solid-state image sensing device **2**, when the signal adding/averaging unit **26**_d_ averages image signals, resolution conversion is performed with use of the number of operation pixels based on sum_ave.

FIG. **15** illustrates a first operation example of the modified example of the solid-state image sensing device **2** illustrated in FIG. **14**. FIG. **16** illustrates a second operation example of the modified example of the solid-state image sensing device **2** illustrated in FIG. **14**. The signal adding/averaging unit **26**_d_ averages image signals, so that a light shot noise (a shot noise with a value of 10 is assumed to be overlapped on the signals **1** and **2**) overlapped on effective image data before averaging is reduced to 1/(positive square root of the number of operation pixels).

In the first operation example (FIG. **15**), the modified example of the solid-state image sensing device **2** reduces the light shot noise to 7. More specifically, in the modified example of the solid-state image sensing device **2**, the S/N ratio before averaging the image signals is 600/10=60, whereas the S/N ratio after averaging the image signals is 600/7=86.

In the second operation example (FIG. **16**), the modified example of the solid-state image sensing device **2** reduces the light shot noise to 6. More specifically, in the modified example of the solid-state image sensing device **2**, the S/N ratio before averaging the image signals is 600/10=60, whereas the S/N ratio after averaging the image signals is 600/6=100.

Thus, the modified example of the solid-state image sensing device **2** can enhance the S/N ratio (enhance the image quality) while securing the dynamic range in both the first operation example and the second operation example.

A description is now given of an example of an apparatus configuration in a case where the solid-state image sensing device **2** according to the embodiments is incorporated in the image reading apparatus **3**. FIG. **17** is a side view of the image reading apparatus **3** which incorporates the solid-state image sensing device **2** according to the embodiments.

A document laid on a contact glass **300** is pressed with a pressurizing plate **318** so as to prevent displacement. The light source **30** for document irradiation irradiates the document with light. Reflected light from the document is reflected by three mirrors **308**, **310** and **312**, and inputted into the solid-state image sensing device **2** mounted on a board **316** via a lens **314**.

The solid-state image sensing device **2** outputs an analog signal which is an image signal in accordance with the amount of inputted light. The analog signal is converted into a digital signal by the A/D conversion unit **22** (see FIG. **5**) in the solid-state image sensing device **2**. The converted signal is then subjected to specified image processing executed by an unshown image processing unit **34** (see FIG. **11**), and is temporarily stored in an unshown storage device.

A reference value of the analog signal is the value obtained when reflected light from a reference white board **302** is inputted into the solid-state image sensing device **2**. A first carriage **304** having the light source **30** and the mirror **308**, and a second carriage **306** having the mirrors **310** and **312** perform scan in a direction approaching the solid-state image sensing device **2** in order to read the document. The image reading apparatus **3** may be configured such that the light source, the mirrors, the lens and the solid-state image sensing device **2** are integrated to scan and read the document.

A description is now given of an image forming apparatus **4** which incorporates the image reading apparatus **3** having the solid-state image sensing device **2**. FIG. **18** is a side view of the image forming apparatus **4** which incorporates the image reading apparatus **3** having the solid-state image sensing device **2**.

The image reading apparatus **3** is utilized as an image scanner, which is used as an image input apparatus for personal computers (PCs) and the like, or is utilized as a document reading unit in the image forming apparatus **4**, such as a copying machine, a fax machine, and a printer.

The image forming apparatus **4** includes an image forming apparatus body **500**, an image reading apparatus **3** placed in an upper portion of the image forming apparatus body **500**, an automatic document feeder (hereinafter referred to as "ADF") **600** mounted on top of the image reading apparatus **3**, a large-capacity sheet feeder **700** arranged on the right-hand side of the image forming apparatus body **500** in FIG. **18**, and a sheet post-processing apparatus **800** arranged on the left-hand side of the image forming apparatus body **500** in FIG. **18**.

The image forming apparatus body **500** is an image forming section which is made up of an image writing unit **510**, an image forming unit **520**, a fixing unit **530**, a double-sided conveying unit **540**, a sheet feeding unit **550**, a vertical conveying unit **560**, and a manual feeding unit **570**. The image writing unit **510** modulates an LD used as a light source based on image information on the document read with the image reading apparatus **3**, and performs laser write onto a photoconductor drum **521** with a scanning optical system including a polygon mirror and an fe lens. The image forming unit **520** is made up of the photoconductor drum **521** and publicly known electrophotographic image forming elements, such as a developing unit **522**, a transfer unit **523**, a cleaning unit **524**, and a neutralizing unit, provided along an outer circumference of the photosensitive drum **521**.

The fixing unit **530** fixes an image transferred with the transfer unit **523** onto a transfer sheet. The double-sided conveying unit **540** includes a first switching claw **541** provided downstream of the fixing unit **530** in a transfer sheet conveying direction, for switching the transfer sheet conveying direction toward the sheet post-processing apparatus **800** or the double-sided conveying unit **540**, a reverse conveying path **542** in which the transfer sheet is led by the first switching claw **541**, an image forming-side conveying path **543** for conveying the transfer sheet reversed in the reverse conveying path **542** toward the transfer unit **523** again, and a post processing-side conveying path **544** for conveying the reversed transfer sheet toward the sheet post-processing apparatus **800**. A second switching claw **545** is provided at a branch point between the image forming-side conveying path **543** and the post processing-side conveying path **544**.

The sheet feeding unit **550** includes four feeding stages. A transfer sheet contained in the selected feeding stage is drawn out and is guided to the vertical conveying unit **560** by a pickup roller and a feed roller. In the vertical conveying unit **560**, the transfer sheet fed from each feeding stage is conveyed to a registration roller **561** which is immediately before the transfer unit **523** in the sheet conveying direction. In the registration roller **561**, the transfer sheet is fed into the transfer unit **523** in synchronization with the leading end of an image developed on the photoconductor drum **521**. The manual feeding unit **570** has a manual feeding tray **571** which is freely opened and closed. The manual feeding tray **571** is opened to manually feed a transfer sheet as necessary. Also in this case, the registration roller **561** sets the conveyance timing of the transfer sheet, and the transfer sheet is conveyed accordingly.

The large-capacity sheet feeder **700** is adapted to stack and feed transfer sheets of the same size in large quantities. As the transfer sheets are consumed, a bottom plate **702** goes up so that a pickup roller **701** can pick up a transfer sheet. The transfer sheet fed from the pickup roller **701** is conveyed through the vertical conveying unit **560** to a nip of the registration roller **561**.

The sheet post-processing apparatus **800** is adapted to execute specified processing, such as punching, aligning, stapling, and sorting. In this embodiment, the sheet post-processing apparatus **800** has a punch **801**, a staple tray (aligning) **802**, a stapler **803**, and a shift tray **804** for the aforementioned functions. More specifically, in the case of punching the transfer sheets which are delivered from the image forming apparatus body **500** into the sheet post-processing apparatus **800**, the sheets are punched one sheet at a time with the punch **801**. If no more processing is performed, the punched sheets are discharged to a proof tray **805**. If sorting, stacking and sorting are to be performed, the sheets are discharged to the shift tray **804**. In this embodiment, sorting is implemented by reciprocating the shift tray **804** for a specified amount in a direction orthogonal to the sheet conveying direction. Or alternatively, sorting may be implemented by moving the sheets in a direction orthogonal to the sheet conveying direction in the paper conveying path.

In the case of aligning the sheets, the punched or unpunched transfer sheets are guided to a lower conveying path **806**, and in the staple tray **804**, the direction of the sheets orthogonal to the sheet conveying direction is aligned with use of a rear end fence, and the direction of the sheets parallel to the sheet conveying direction is aligned with use of a jogger fence. Here, if binding is to be performed, an aligned paper sheet bundle is bound at a specified position, such as a corner section and two center sections, by means of the stapler **803**. The bound paper sheet bundle is discharged to the shift tray **804** with use of a discharge belt. In this embodiment, the lower conveying path **806** is provided with a pre-stack conveying path **807**. The pre-stack conveying path **807** can stack two or more sheets while the sheets are being conveyed so as to avoid interruption of image forming operation in the image forming apparatus body **500** during post processing operation.

The image reading apparatus **3** optically scans a document which is guided by the ADF **600** onto a document table **330** and stops thereon. The image reading apparatus **3** uses the solid-state image sensing device **2** to read a read target image which has travelled through the first through third mirrors and imaged with an image formation lens. Specified image processing is performed on the read image data in an unshown image processing circuit, and the data is temporarily stored in a storage device. Then, at the time of image formation, the image writing unit **510** reads out the image data from the storage device, performs modulation according to the image data, and performs optical writing.

The embodiment provides the advantage of preventing the dynamic range of image data from being narrowed even when resolution conversion is performed.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. A solid-state image sensing device comprising:

circuitry configured to:

convert light into electrical signals for respective pixels, and output the electrical signals;

separate an offset signal, which is generated due to dark current, from each of the electrical signals to generate image signals, and output the image signals for the respective pixels; and

add, for each group of a plurality of pixels, the image signals of the plurality of pixels,

wherein the circuitry is configured to obtain an image signal after resolution conversion is performed for resolution reduction by addition of the image signals for each group of the plurality of pixels.

2. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to:

perform A/D conversion of the electrical signals, and

separate the offset signal, which is generated due to the dark current, from each of the electrical signals obtained by the A/D conversion, and output the image signals which are digital signals of the respective pixels.

3. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to perform A/D conversion of each of the image signal obtained by addition for each group of the plurality of pixels.

4. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to add the image signals for each group of the plurality of pixels, a number of the image signals corresponding to a ratio between resolutions before and after resolution conversion performed for resolution reduction.

5. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to add the image signals for each group of the plurality of pixels, a number of the image signals being a maximum integer equal to or less than a ratio between resolutions before and after resolution conversion performed for resolution reduction.

6. An image reading apparatus comprising a solid-state image sensing device, wherein

the solid-state image sensing device comprises:

circuitry configured to:

convert light into electrical signals for respective pixels, and output the electrical signals;

separate an offset signal, which is generated due to dark current, from each of the electrical signals to generate image signals, and output the image signals for the respective pixels; and

add, for each group of a plurality of pixels, the image signals of the plurality of pixels,

wherein the circuitry is configured to obtain an image signal after resolution conversion is performed for resolution reduction by addition of the image signals for each group of the plurality of pixels.

7. An image reading apparatus comprising the solid-state image sensing device according to claim **1**, wherein

when an image reading period in a sub-scanning direction is shortened in accordance with resolutions in resolution conversion performed for resolution reduction, the circuitry is configured to add the image signals for each group of the plurality of pixels, a number of the image signals corresponding to a ratio between image reading periods in the sub-scanning direction before and after the resolution conversion.

8. An image reading apparatus comprising the solid-state image sensing device according to claim **1**, wherein

when an amount of light from a light source is reduced in accordance with resolutions in resolution conversion performed for resolution reduction, the circuitry is configured to add the image signals for each group of the plurality of pixels, a number of the image signals corresponding to a ratio between amounts of light from the light source before and after the resolution conversion.

9. An image forming apparatus comprising:

the image reading apparatus according to claim **6**; and

an image former that forms an image read by the image reading apparatus.

10. An image forming apparatus comprising:

the image reading apparatus according to claim **7**; and

an image former that forms an image read by the image reading apparatus.

11. An image forming apparatus comprising:

the image reading apparatus according to claim **8**; and

an image former that forms an image read by the image reading apparatus.

12. A solid-state image sensing device comprising:

circuitry configured to:

convert light into electrical signals for respective pixels, and output the electrical signals;

separate an offset signal, which is generated due to dark current, from each of the electrical signals to generate image signals, and output the image signals for the respective pixels; and

average, for each group of a plurality of pixels, the image signals of the plurality of pixels,

wherein the circuitry is configured to obtain an image signal after resolution conversion is performed for resolution reduction by addition of the image signals for each group of the plurality of pixels.

13. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to receive the electrical signals, convert the electrical signals into parallel bits of digital signals, and output the converted electrical signals.

14. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to add the image signals for each group of a plurality of consecutive pixels.

15. The solid-state image sensing device according to claim **13**, wherein the circuitry is configured to separate the offset signal from each of the converted electrical signals to generate the image signals.

16. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to separate the offset signal by digital correlated double sampling.

17. The solid-state image sensing device according to claim **1**, wherein the circuitry is configured to separate the offset signal from each of the electrical signals after the electrical signals are converted into digital signals.

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